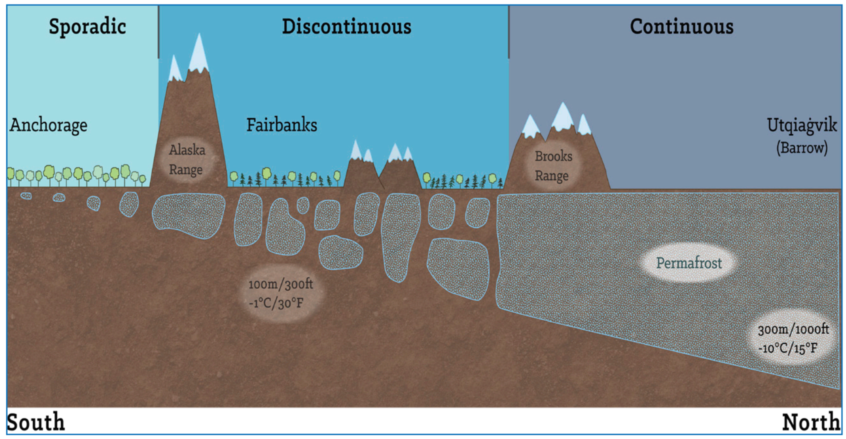
PERMAFROST OVERVIEW

2022

WHAT IS PERMAFROST?

Permafrost is frozen ground that can range in depth from shallow surface areas to thousands of feet, as shown in the figure on the right.

Areas of continuous permafrost underlie the Alaska Arctic Coastal Plain. Between the Alaska Range and the Brooks Range, the permafrost is discontinuous—50-90% of the land is underlain with frozen soil near the thaw point (UAF, n.d.). In this zone, it is often difficult to determine the presence and predict permafrost behavior, presenting a significant risk to the built infrastructure.



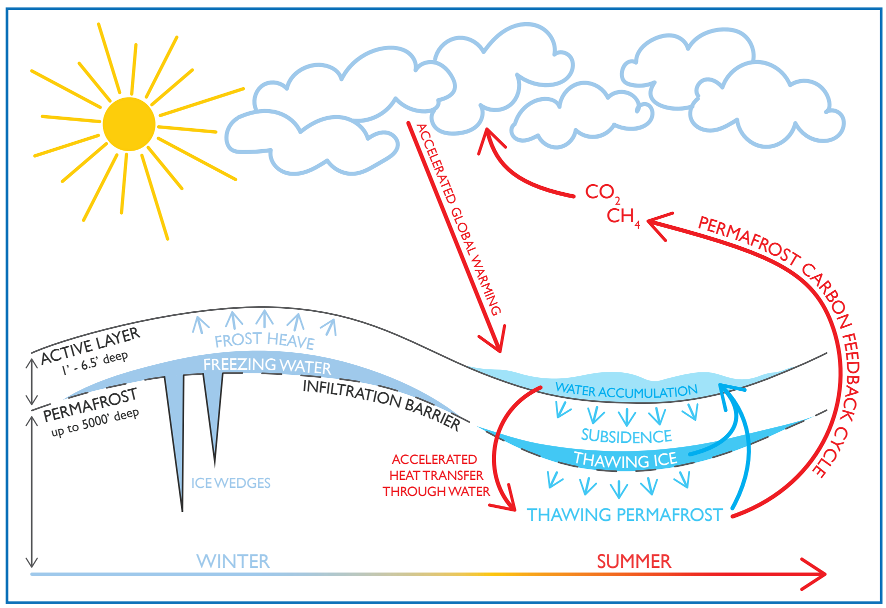
Permafrost Land Cover

Illustration from Foss & Rudolf, University of Alaska Fairbanks

PERMAFROST BEHAVIOR

Various factors directly affect permafrost behaviour, including ice content, water, temperature, shading, and human activity. Damage to boreal forests or the tundra can eventually strip the ground of insulation, speeding up thaw and subsidence and transforming the landscape in a way that naturally could take hundreds of years.

The active layer is a thinner layer of soil on top of permafrost. Unlike permafrost, it freezes and thaws annually instead of staying consistently frozen. Its name comes from its ability to support life (vegetation). The movement of water to the freezing front causes ice lens formation that can cause the ground to rise. This is known as **frost heave**. Similarly, as ice thaws it can cause the ground to sink. This is known as **subsidence**.



Permafrost Water Cycle

Illustration by Milena Coakley, NREL

When air temperatures decrease abruptly, cracks can form in the ground, allowing water to infiltrate. When this water freezes, it can lead to the creation of ice wedges, which create a plane of weakness for a new crack to form the subsequent winter, allowing more water to enter. Ice wedges can grow over the course of centuries or millennia. When ice wedges or other massive ice formations melt, they create large troughs in the ground.

COLD CLIMATE HOUSING RESEARCH CENTER

NNA Ice-Rich Permafrost Systems IRPS

UAF UNIVERSITY OF ALASKA FAIRBANKS

NREL

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PERMAFROST CONCERNS

INFRASTRUCTURE

Permafrost's most challenging characteristics arise from **water**. Permafrost below the active zone prevents infiltration, resulting in increased surface water and flooding of low areas during early thaw periods. Water within the active layer and pooling at the surface accelerates ice-rich permafrost and ice-wedge thaw by increasing heat transfer from the atmosphere to the frozen soil. This creates a cycle in which the thaw of permafrost continues to accelerate itself.

There are a few strategies for building on permafrost. Depending on location and conditions, preserving it in its frozen state, intentionally thawing it, or removing and replacing the frozen soil are all viable options. One can also build in a location where settlement associated with thawing permafrost would not compromise the integrity of the structure.

CARBON RELEASE

Thawing Yedoma (permafrost containing a significant amount of organic material) releases carbon dioxide and methane into the atmosphere. Over time, increasing amounts of these greenhouse gases accumulate in the atmosphere, where they trap solar radiation. The resulting global temperature increase leads to additional permafrost degradation, a cycle known as permafrost carbon feedback. This effect is enhanced when the process occurs quickly (i.e., days to years; Miner et al. 2022). Measuring these gases on a global scale (particularly methane) is challenging, and modeling this process is an ongoing effort for climate scientists.

COASTAL EROSION

Thawing permafrost can increase the rate of coastal erosion, as the structural integrity of the soils is mainly due to the high ice content. Decreased amounts of coastal sea ice mean less protection from storm surges. Coastal erosion endangers many communities in Alaska and has already forced entire villages to relocate.

Exposed Permafrost *Photo from Vladimir Romanovsky, University of Alaska Fairbanks*

Text References

Miner, K.R., Turetsky, M.R., Malina, E. et al. 2022. Permafrost carbon emissions in a changing Arctic. *Nat Rev Earth Environ 3, 55–67. <https://doi.org/10.1038/s43017-021-00230-3>*

UAF (n.d.) Accessed January 21, 2022. Permafrost in Alaska. *Hot Times in Cold Places - Permafrost during Climate Change. <http://www.permafrosttunnel.org/permafrost-in-alaska.html>*

Images

Foss and Rudolf n.d., Permafrost Land Cover, illustration recieved from the Author June 29, 2022.

Romanovsky n.d., Exposed Permafrost, accessed 24 June, 2022, <https://www.pmel.noaa.gov/arctic-zone/permafrost-photos/web_2011/2006%20017.jpg>

Permafrost Resources

- Permafrost Tunnel
- UAF Geophysical Institute
- Informational Video on Permafrost, AWI
- Map of Permafrost in Alaska
- National Resources Defense Council
- National Snow and Ice Data Center
- UN Environment Programme

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